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(54) CROSS-TALK REDUCING PRINTED CIRCUIT BOARD FOR A SWITCHING NETWORK

(71) We PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a printed circuit board for a switching network, comprising printed tracks and connections for a plurality of switching members to be located on the board.

Printed circuit boards are generally used. United States Patent Specification 3,496,555 describes a magnetic memory apparatus comprising a printed circuit board in which a drive winding is formed by a first pair of printed tracks and a sense winding is formed by a second pair of printed tracks. So as to eliminate cross-talk between the drive winding and the sense winding, the sense winding is provided with a cross-over which divides the sense winding into two equally large loops which are coupled to the sense winding in an opposite sense with respect to each other. Consequently, the cross-talk signals induced in the two loops are equally large but have opposite polarity, so that they cancel. The cross-over is realized by means of two additional interconnections.

A printed circuit board for a switching network comprises connections for switching members which are inserted in the printed tracks. A problem exists in that other parts of the printed tracks are included or are not included in a signal path, depending on whether each of the switching members is in the active or in the rest state, so that cross-talk reduction must be effected for a signal path which has a variable location on the printed circuit board and hence a variable length.

The invention has for its object to realize cross-talk reduction for this type of printed circuit board in a very simple manner with a minimum number of additional interconnections.

According to the invention there is provided a printed circuit board for a switching network, printed tracks and connections for a plurality of switching members to be located on the board, in which the printed tracks and connections are arranged so that the operation of each switching member establishes a selected four-wire signal path, and in which at the location of at least some of the switching members a circuit cross-over is provided between two printed tracks, the cross-overs being arranged in relation to the switching member connections such that each selected four-wire signal path includes one or more of the cross-overs whereby cross-talk in that signal path is reduced.

The invention and its advantages will be described in detail hereinafter with reference to the figures.

Fig. 1 shows an embodiment of a printed circuit board according to the invention, and Fig. 2 shows a switching member as used in the embodiment of Fig. 1.

Fig. 1 shows a printed circuit board 25 accommodating that part of the wiring for a switching network comprising eight switching members which is of importance to the invention. This wiring is provided in the form of printed tracks, both on the upper surface (represented by solid lines) and on the lower surface (represented by broken lines).

The printed tracks provided on the upper surface are connected to the printed tracks provided on the lower surface by means of interconnections in the form of plated-through holes (denoted by dots).

For the sake of simplicity of Fig. 1, the switching members are not shown in this figure; a switching member is separately shown in Fig. 2. These switching members, for example, read relays, comprise four contacts 32 to 35. These contacts are closed in the active state, thus interconnecting the

connection terminals 36 to 39 with the connection terminals 40 to 43.

Stroke-dot lines in Fig. 1 denote the locations 17 to 24 where the eight switching members are to be provided. Per location eight interconnections are provided to which the connection terminals of the switching members are conductively connected. For example, at the location 17 the interconnections 17-6 to 17-13 are provided, which are connected to the connection terminals 36 to 43 of a switching member which is not shown.

Also provided on the printed circuit board are four groups 0-1 to 0-4 of four input terminals each, and two groups 0-5, 0-6 of four output terminals each. So as to enable random connection of each group of input terminals 0-1, 0-2, 0-3 or 0-4 to each group of output terminals 0-5 or 0-6, the locations 17 to 24 in which the switching members are provided are divided into two rows, each row comprising four locations 17 to 20 and 21 to 24, respectively. On the one side, the switching members of the locations 17 and 21, 18 and 22, 19 and 23, 20 and 24 are connected in pairs to the input terminal groups 0-1, 0-2, 0-3 and 0-4, respectively, *via* two pairs of conductors 1 and 2, 3 and 4, 5 and 6, 7 and 8, respectively, each of which comprises two printed tracks 1-1, 1-2 and 2-1, 2-2; 3-1, 3-2 and 4-1, 4-2; 5-1, 5-2 and 6-1, 6-2; 7-1, 7-2 and 8-1, 8-2, respectively. On the other side, the switching members of the locations 17 to 20 and 21 to 24 are connected per row, *via* two pairs of conductors 9 and 10 and 11 and 12, respectively, each comprising two printed tracks 9-1, 9-2 and 10-1, 10-2, and 11-1, 11-2 and 12-1, 12-2, respectively, to two pairs of conductors 13 and 14, and 15 and 16, respectively, each of which comprises two printed tracks 13-1, 13-2 and 14-1 14-2 and 15-1, 15-2 and 16-1, 16-2, respectively. These pairs of conductors 13 and 14, and 15 and 16 are connected to the output terminal group 0-5 and 0-6, respectively.

As appears from Fig. 1, the pairs of conductors 1, 3, 5, 7, 9, 11, 13 and 15 extend parallel to and at a short distance from the pairs of conductors 2, 4, 6, 8, 10, 12, 14 and 16. A current flowing in the odd pairs of conductors incorporated in a signal path between one of the groups of input terminals 0-1, 0-2, 0-3 or 0-4 and one of the groups of output terminals 0-5, 0-6 induces a voltage in the adjacently arranged even pairs of conductors, and *vice versa*. These undesired induced voltages are referred to as cross-talk signals. So as to suppress this cross-talk, it is known to provide a cross-over in one pair of conductors by means of two additional interconnections about halfway along the signal path. The cross-talk signals induced in the conductor pairs in one half of the signal path are then in phase-opposition with and approximately as large as the cross-talk signals induced in the conductor pairs of the other half of the signal path, so that these cross-talk signals eliminate each other. In a printed circuit board 1 for a switching network as shown in Fig. 1, a problem arises because the fact whether or not the switching members which are provided in the locations 17 to 24 are closed determines which pairs are included in a signal path and which pairs are not included. As a result, the location of the signal path, and hence the length of the signal path, is different each time.

As is shown in Fig. 1, cross-overs are realized at the locations of at least some of the switching members so as to enable a simple suppression of cross-talk signals in any signal path which can be established by means of the switching members. To this end, the printed tracks 1-1, 1-2, and 2-1, 2-2 are connected, at the location 17 *via* the interconnections 17-14 to 17-17 and the printed tracks 17-1 to 17-4, to the interconnections 17-6 to 17-9, and the printed tracks 13-1, 13-2 are connected to the interconnections 17-10, 17-11, whilst the printed track 14-1 is connected, *via* an additionally provided interconnection 17-18 and the printed tracks 10-2, to the interconnection 17-13, the printed track 14-2 being directly connected to the interconnection 17-12. It is thus achieved that, when the switching member provided in the location 17 is in the active state, the conductor pair 1 is cross-wise connected to the conductor pair 14, at the location 17, and the conductor pair 2 is connected without crossing to the conductor pair 13. The pairs of conductors 1 and 2 have the same length as the pairs of conductors 13 and 14, so that the cross-talk signals in the four-wire signal path which is established between the input terminals 0-1 and the output terminals 0-5 as a result of the active state of the switching member provided in location 17, fully eliminate each other.

Furthermore, at the location 18 the printed tracks 3-1, 3-2 and 4-1, 4-2 are connected, *via* the interconnections 18-14 to 18-17 and the printed tracks 18-1 to 18-4, to the interconnections 18-6 to 18-9, and the interconnections 18-10 to 18-13 are connected, *via* the printed tracks 9-1, 9-2 and 10-1, 10-2, to the interconnections 17-10 to 17-13. It is thus achieved that, when the switching member which is provided in the location 18 is in the active state, a four-wire signal path is established between the input terminals 0-2 and the output terminals 0-5, the conductor pair 3 being connected without crossing at the locations 17, *via* the conductor pair 9, to the conductor pair 13, the conductor pair 4 being cross-wise connected, *via* the conductor pair 10, to the pair of conduc-

tors 14. The length of the pairs of conductors 3 and 4 is the same as that of the pairs of conductors 13 and 14, so that the cross-talk signals induced in these conductor pairs eliminate each other. However, no cross-talk compensation is effected for the part of the signal path which is formed by the parts of the conductor pairs 9 and 10 which are situated between the locations 17 and 18. In order to keep the cross-talk in this compartively small part of the signal path as small as possible, the printed tracks 9-1, 9-2 are provided at a comparatively large distance from the printed tracks 10-1, 10-2.

Furthermore, at the location 19 the printed tracks 5-1, 5-2 are connected to the interconnections 19-6, 19-7 *via* the interconnections 19-14, 19-15 and the printed tracks 19-1, 19-2, and the printed track 6-1 is connected, *via* the interconnection 19-17 and the printed track 19-4, to the interconnection 19-9, the printed track 6-2 being connected, *via* the interconnection 19-16 and the printed track 19-3, to the interconnection 19-18. Moreover, at the location 18 a cross-over is provided by means of only one additional interconnection 18-18, and the printed track 10-2 is led, *via* the interconnection 18-13, to the upper surface where it crosses the printed track 19-1 which is situated on the lower surface, and is subsequently returned to the upper surface *via* the interconnection 18-18. It is thus achieved that the interconnections 19-12 and 19-13 are connected, *via* the printed tracks 10-2 and 10-1, to the interconnections 17-13 and 17-12, whilst the printed tracks 9-1 and 9-2 are connected to the interconnections 17-10 and 17-11.

When the switching member which is provided in the location 19 is in the active state, a four-wire signal path exists between the input terminals 0-3 and the output terminals 0-5, the conductor pair 5 being connected without crossing in the location 17, *via* the conductor pair 9, to the conductor pair 13, the conductor pair 6 being cross-wise connected at the location 19 to the conductor pair 10 which is provided with a cross-over at the location 18 and which is connected without crossing to the conductor pair 14. On the one side, the conductor pair 5 of the signal path is thus coupled to the conductor pair 6 in the same manner as the parts of the conductor pairs 9 and 10 which are situated between the locations 17 and 18 are coupled to each other, but on the other side they are coupled to conductor pair 6 in a way opposite to that in which the conductor pairs 13 and 14 are coupled to each other, and in which the parts of the conductor pairs 9 and 10 which are situated between the locations 18 and 19 are coupled to each other. Because, as is shown in Fig. 1, the length of the parts of the pairs of conductors 9 and 10 which are situated between the locations 17 and 18 is approximately equal to the length of these pairs of conductors between the locations 18 and 19, and because the length of the pairs of conductors 5 and 6 is equal to the length of the pairs of conductors 13 and 14, the cross-talk signals induced in the four-wire signal path eliminate each other completely.

In the same way as in which at the location 19 the pairs of printed tracks 5-1, 5-2 and 6-1, 6-2 are connected to the interconnections 19-6 to 19-9 and the interconnections 19-10 to 19-13 are connected to the printed tracks 9-1, 9-2 and 10-2, 10-1, the pairs of printed tracks 7-1, 7-2 and 8-1, 8-2 are connected at the location 20 to the interconnections 20-6 to 20-9, and the interconnections 20-10 to 20-13 are connected to the printed tracks 9-1, 9-2 and 10-2, 10-1. When the switching member which is provided in the location 20 is in the active state, a four-wire signal path is thus established between the input terminals 0-4 and the output terminals 0-5 in which the induced cross-talk signals eliminate each other in a manner which is identical to the described manner, with the exception of the parts of the conductor pairs 9 and 10 which are situated between the locations 19 and 20. For the part of the core pairs 9 and 10 in which the induced cross-talk signals are not eliminated, it applies again that these parts have only a limited length and that the printed pairs of tracks 9-1, 9-2 and 10-1, 10-2 are situated at a compartively large distance from each other. It follows that a part of a printed track which is not compensated for cross-talk always constitutes a small part of the overall print length of a signal path, the said length never being larger than the distance between two adjacent switching members, and the said part always being situated in printed tracks which are only very weakly coupled to each other, with the result that these cross-talk signals are negligibly small.

The pairs of conductors 1 to 4 are coupled to the switching members which are provided in the locations 21 and 22 in the same manner as the pairs of conductors 5 to 8 are coupled to the switching members provided in the locations 19 and 20, and the pairs of conductors 5 to 8 are connected to the switching members provided in the locations 23 and 24 in the same way as the pairs of conductors 1 to 4 are connected to the switching members provided in the locations 17 and 18. The switching members which are provided in the locations 21 and 24 are interconnected, *via* the pairs of conductors 11 and 12, in the same manner as the switching members provided in the locations 17 to 20 are interconnected by means of the pairs of conductors 9 and 10, the conductor pair 12 being provided with a cross-over at the location 22 by means of an additional inter-

connection 22-18. At the location 23, the conductor pairs 15 and 16 which are connected to the output terminal group 0-6 are connected to the conductor pairs 11 and 12, notably the printed track 16-1 being connected to the printed track 12-1 by means of the additionally provided interconnection 23-18. As a result of this method of connecting the conductor pairs 1 to 8 and 11, 12, 15 and 16 to the switching members provided in the locations 21 to 24 it is achieved, when one of these switching members is set to the active state, that a four-wire signal path is closed, between the input terminal group connected to this switching member and the output terminal group 0-6, in which induced cross-talk signals eliminate each other.

It is to be noted that a substantial reduction of the number of interconnections can be achieved by using two kinds of switching members, the connection terminals 36 to 39 thereof then being situated, instead of their situation in the switching member as shown in Fig. 2, for a first kind of switching member, for example, like the interconnections 17-14 to 17-17, and for a second kind of switching member, for example, like the interconnections 20-14 to 20-17.

WHAT WE CLAIM IS:—

1. A printed circuit board for a switching network, in which the board comprises printed tracks and connections for a plurality of switching members to be located on the board, in which the printed tracks and connections are arranged so that the operation of each switching member establishes a selected four-wire signal path, in which at the location of at least some of the switching members a circuit cross-over is provided between two printed tracks, the cross-overs being arranged in relation to the switching member connections such that each selected four-wire signal path includes one or more of the cross-overs whereby cross-talk in that signal path is reduced.

2. A printed circuit board for a switching network, substantially as herein described with reference to the accompanying diagrammatic drawings.

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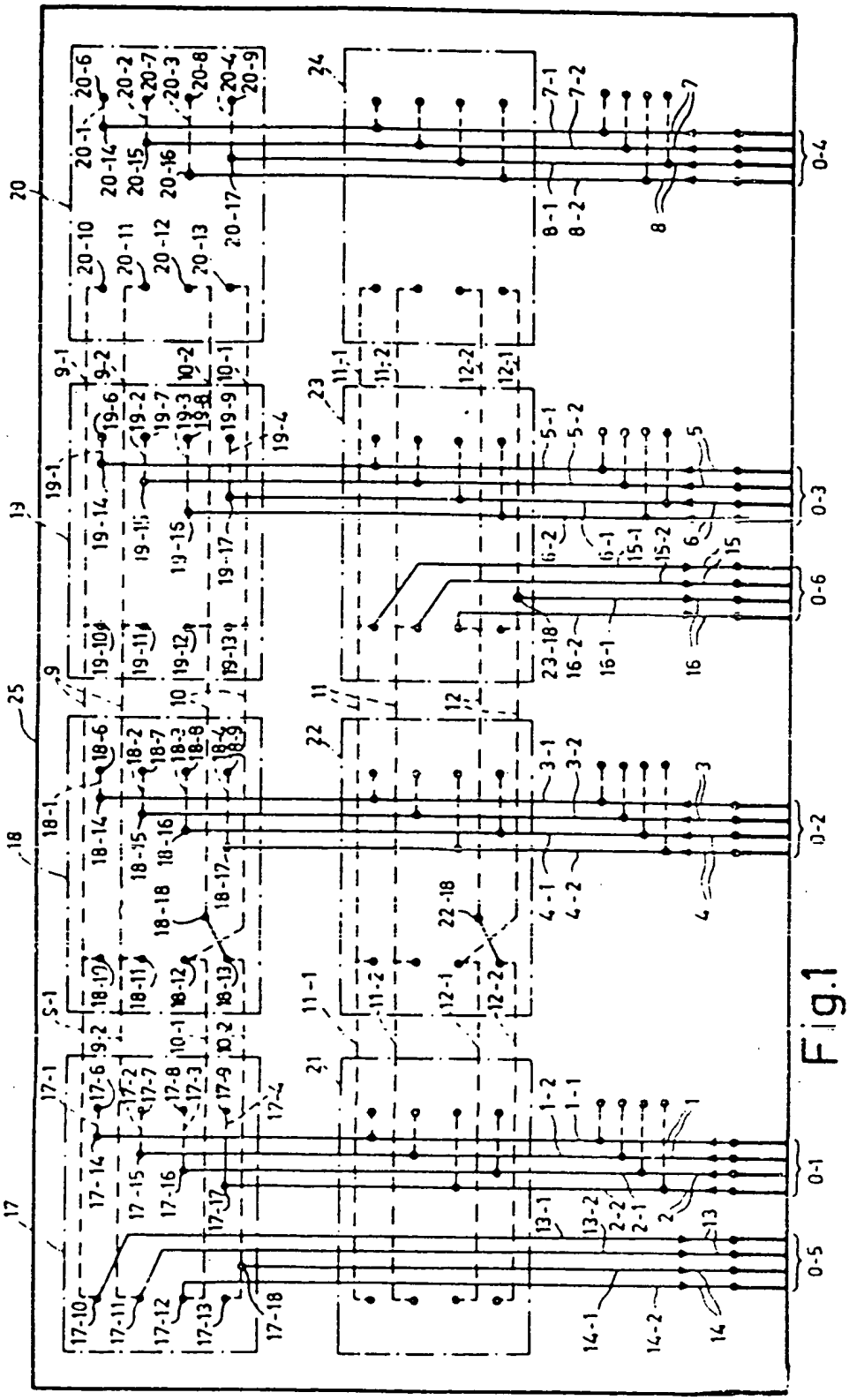

Fig.1

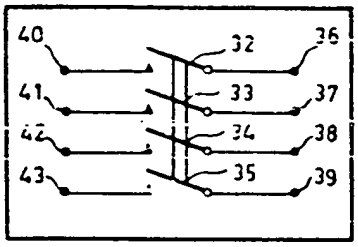

Fig.2

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